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Comparative Study of Liquid Biofuel Production Pathways for a Sustainable Mobility Solution

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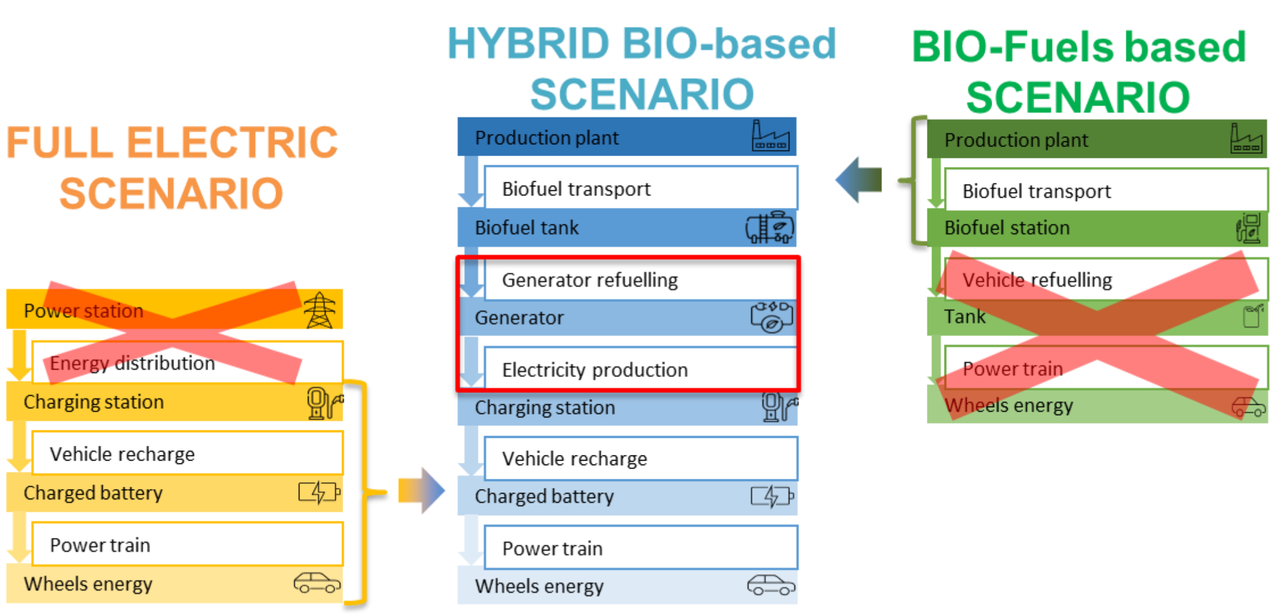
INTRODUCTION & AIM

Biofuels are, and will remain, essential components of sustainable mobility. Their future deployment, however, depends on the availability of sustainable feedstocks, the maturity of conversion technologies, and the stringent EU regulatory framework governing emissions. The objective of this study is to quantitatively assess the performance of multiple biorefinery pathways for liquid biofuel production. Evaluations are intended to inform the feasibility assessment of an innovative sustainable mobility system, the Off-Board Hybrid, consisting of a liquid-biofuel-fired electric generator operating in island mode and coupled to electric vehicle charging stations.

METHOD

We processed modeling yields, energy consumption, utility needs, and equipment sizing for each biofuel production pathway. To ensure comparability, costs are typically expressed in €/GJ of fuel, as different biofuel types have highly variable energy densities (e.g., 44 MJ/kg for renewable diesel vs. <20 MJ/kg for biomethanol). These approaches reveal, for example, that biofuels from dedicated crops face high cultivation emissions unless marginal/contaminated lands are valorized.



RESULTS & DISCUSSION

Energy yield measures energy recovery from feedstock to biofuel, highlighting the clear superiority of catalytic processes from vegetable oils over thermochemical or biochemical routes from lignocellulosics. This is largely due to the higher energy content (LHV of the feedstock) and purity (triglycerides) of oils. Catalytic oil-based processes remain the best performers, but its gap with others narrows. Some thermochemical routes with targeted inputs (biocrude, pyro-oil, EtOH) gain competitiveness, showing sensitivity to reliance on supplementary energy vectors—even for non-oil biofuels (MeOH via enrichment).

CONCLUSION

The results provide a quantitative comparison of the techno-economic and environmental performance of the examined pathways and identify feedstock, scale and integration conditions that enhance pathway competitiveness. Evaluations are intended to inform the feasibility assessment of an innovative sustainable mobility system, the Off-Board Hybrid.

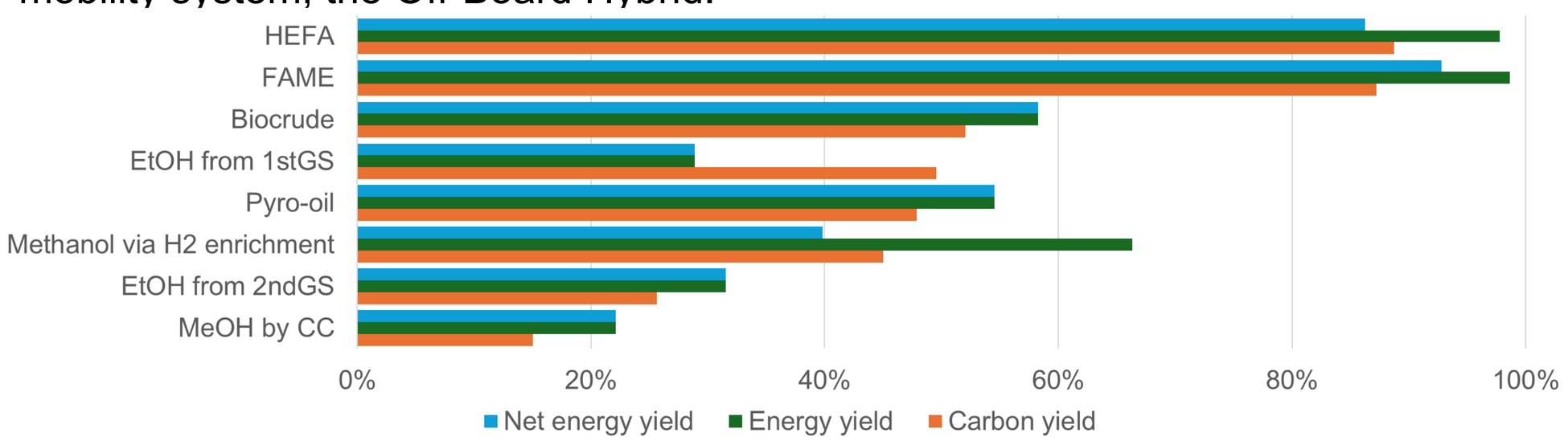


Figure 1: Biofuel production performances